In the wake of Bolund: Benakanahalli - Stratification and complex terrain

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BENAKANAHALLI: IN THE WAKE OF BOLUND
Stratification and Complex Terrain

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Introduction

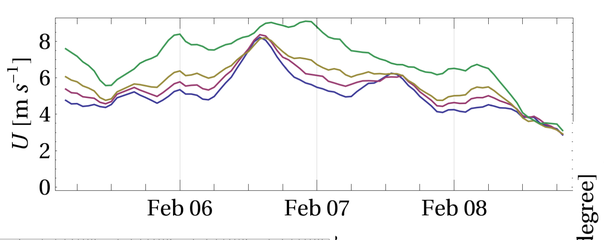
In early 2010 a new field experiment, close to the village of Benakanahalli, focusing on micro meteorological properties important for wind energy were conducted in the region of Karnataka, India. The field experiment is the natural successor to the Bolund Hill experiment (**Boundary Layer Meteorology 141, p. 219 & p. 245, 2011**): The Bolund measurement campaign performed near the Risø campus of DTU Wind Energy, in 2009 provided significant insight into flow in complex terrain and has proven very suitable for benchmarking of models. Even though up-scaling is permitted to some degree, the 12 m tall peninsula, the Bolund Hill, is still too simple for many purposes; it lacks atmospheric stratification and the Coriolis effects. In addition the wake of Bolund was very poorly resolved. The present field campaign focus on exactly those things. i.e. the flow is altered by both the presence of complex terrain and atmospheric stratification and we are thus able to study the combined effects of these upon the flow. This study which should be much welcomed in the wind energy community, since a large part of turbines today are erected exactly at places where these effects are non-negligible.

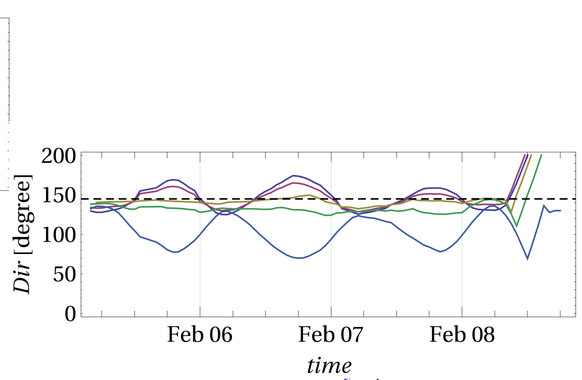
A field experiment at 14° 10' 34" N, 75° 50' 29" E

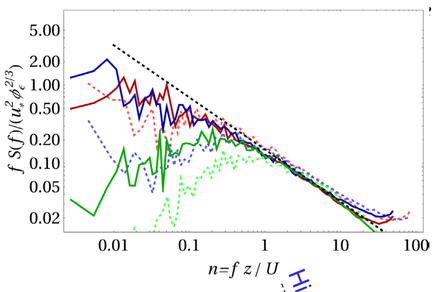
Five 80m masts were erected near and on a long almost two-dimensional 120m natural ridge with slopes of around 35 degrees. Equipped with sonic anemometers in five different heights, both the mean flow and the turbulence are well resolved. In addition temperature sensors were mounted on the upstream mast. Together with measurements of heat fluxes from the sonic anemometers a good estimate of the thermal stratification is thus obtained. Three mast were positioned in the wake of the hill giving us the opportunity to estimate its size and hence the recovery length of the wind speed. For estimation of the boundary layer height a ceilometer was also installed. Due to shortage of electrical power all mast instruments were run by solar power. Data were transmitted by satellite connection to DTU Wind Energy, Denmark.

Key dimensionless numbers: ***Fr*~0.2** (night), ***Ro*~50** *(*night*)*, ***Ro***~400 *(*day*)*

Preliminary data: Roadmap of four days in February 2010 with reversed afternoon surface flow in front and behind of the hill







Speed-up on hill top

High day time <v'v'>

Strong daily variations

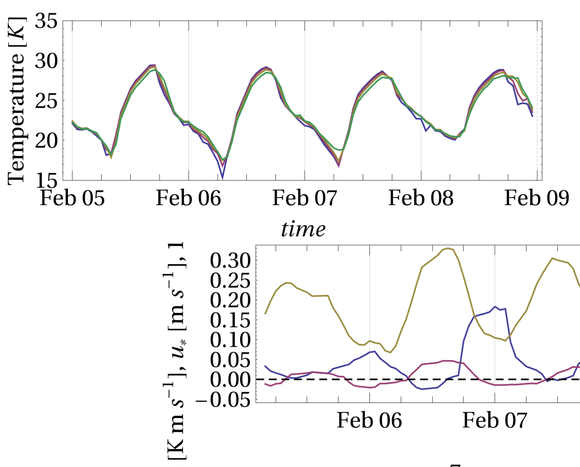
Strong daily variations

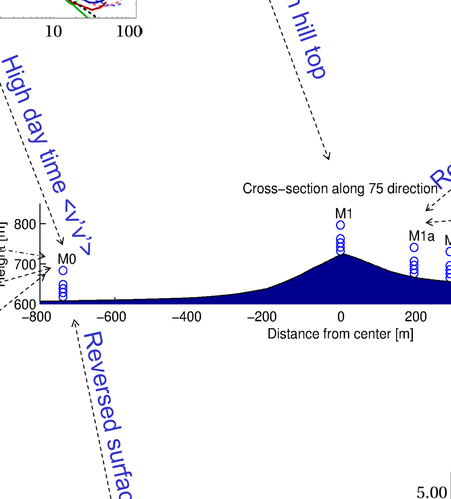
Reversed surface flow in afternoons

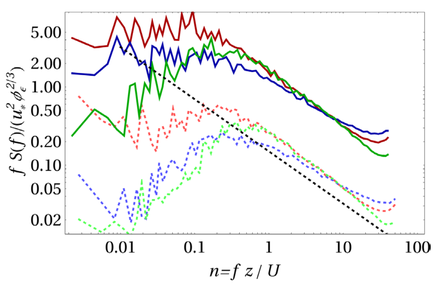
Reversed surface flow in afternoons

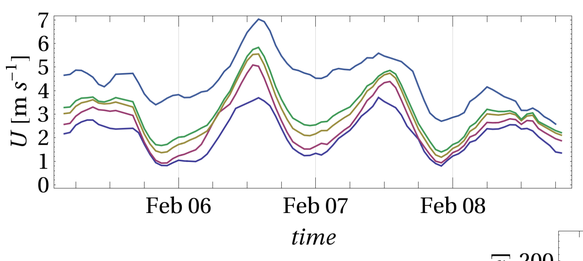
Enhanced turbulence in leaside

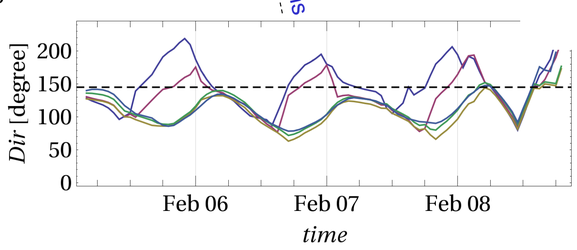
Restored flow

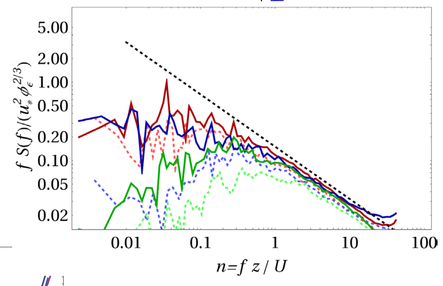












Outlook

Like the Bolund Hill, the Benakanahalli site provides excellent opportunities for testing existing and developing new flow models for use in wind energy. The added complexity of the day - night influence through stability is an extra challenge compared to the Bolund case. During the measurement campaign a WRF meso-scale model has been running covering the site and surroundings. We thus know the meteorology on even larger scales and hence the necessary boundary conditions for successfully mimicking the flow around the Benanakanahalli site. From a boundary layer meteorological point of view, the measurements also give hope for new insights into micro meteorological behavior at low latitudes in complex terrain..